Docket No. ISOT-019

APPLICATION

FOR UNITED STATES LETTERS PATENT

SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT WE, **Paul A. Knight**, a citizen of Canada, and **Carl Axel Ingemar Kabrell**, a citizen of Sweden, have invented a new and useful dry-wet thermal management system of which the following is a specification:

Dry-Wet Thermal Management System

CROSS REFERENCE TO RELATED APPLICATIONS

Not applicable to this application.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable to this application.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to spray cool thermal management devices and more specifically it relates to a dry-wet thermal management system for providing simultaneous spray cooling and dry cooling for a plurality of electronic cards.

Description of the Related Art

The present invention relates to the thermal management of electronic components that are mounted upon electronic cards (a.k.a. expansion boards) or substrates. In a card level system, a plurality of cards are electrically connected within sockets upon a backplane (e.g. motherboard, etc.). Electronic cards are utilized in various applications such as personal computers, workstations, server computers, rack mounted services, network routers, network switches, telephone equipment (DWDMs, ADMs, TDMs, switches, repeaters and the like), and military applications (vehicle, aircraft, etc.). Examples of electronic cards include but are not limited to modems, video processors, network interfaces, processors, memory, hard drive controllers, hard drives, mouse controller, keyboard controller, global position systems, wireless cards, backplane controller cards and the like.

"Dry cooling" (i.e. air cooling) has been in usage for years for cooling electronic components. An example of a dry cooling system is a conventional desktop computer with a fan that passes air over the electronic components to cool the same. Dry cooling technology is acceptable for low powered electronic components.

Modern electronic devices have increased thermal management requirements. Conventional dry cooling technology simply is not capable of efficiently cooling modern high-end electronics. "Spray cooling" is being adopted today as the most efficient option for thermally managing electronic systems. United States Patent No. 5,220,804 entitled High Heat Flux Evaporative Spray Cooling to Tilton et al. describes the earlier versions of spray cooling technology. United States Patent No. 6,108,201 entitled Fluid Control Apparatus and Method for Spray Cooling to Tilton et al. also describes the usage of spray cooling technology to cool a printed circuit board. Spray cooling may be performed locally (i.e. where the chip is sprayed directly), globally (i.e. where the chip and

surrounding electronics/boards are also sprayed), a combination of locally and globally, or in conjunction with air cooling or other cooling methods.

While there are many benefits in utilizing spray cooling technology, there are some detriments. One of the detriments with spray cooling technology is the relatively high cost of creating a spray cooling system capable of thermally managing all of the electronic devices, electronic cards and the like for an electronic system. Another problem with spray cooling technology is the increased weight of the thermal management unit. A further problem with spray cooling technology is that not all electronic devices are suitable for usage within a liquid coolant environment. Another problem with spray cooling technology is that to replace, repair or test any electronic device within a spray chassis the seal must be broken to the spray chassis thereby leading to the loss of coolant.

While these devices may be suitable for the particular purpose to which they address, they are not as suitable for providing simultaneous spray cooling and dry cooling for a plurality of cards sharing a common backplane. Conventional thermal management systems are suitable only for low or high heat flux applications with no thermal management system serving the need for mixed heat flux applications where some electronic devices may be cooled by dry cooling and other electronic devices cooled by spray cooling.

In these respects, the dry-wet thermal management system according to the present invention substantially departs from the conventional concepts and designs of the prior art, and in so doing provides an apparatus primarily developed for the purpose of providing simultaneous spray cooling and dry cooling for a plurality of cards sharing a common backplane.

BRIEF SUMMARY OF THE INVENTION

In view of the foregoing disadvantages inherent in the known types of thermal management devices now present in the prior art, the present invention provides a new dry-wet thermal management system construction wherein the same can be utilized for providing simultaneous spray cooling and dry cooling for a plurality of cards sharing a common backplane.

The general purpose of the present invention, which will be described subsequently in greater detail, is to provide a new dry-wet thermal management system that has many of the advantages of the thermal management devices mentioned heretofore and many novel features that result in a new dry-wet thermal management system which is not anticipated, rendered obvious, suggested, or even implied by any of the prior art thermal management devices, either alone or in any combination thereof.

To attain this, the present invention generally comprises a chassis having a dry chamber and a spray chamber, a first opening within a rear portion of the chassis extending into the spray chamber, a second opening within the rear portion of the chassis extending into the dry chamber, and a main backplane secured and sealed to the rear portion of the chassis. Electronic cards may be electrically coupled within sockets of the main backplane within both the dry chamber and the spray chamber. The cards within the spray chamber are typically high heat flux components with increased cooling requirements and the cards within the dry chamber are typically low heat flux components with reduced cooling requirements. In addition, cards within the dry chamber are sometimes not compatible with the cooling fluid of the spray chamber. A spray cool system is within the spray chamber and a dry cool system is within the dry chamber.

There has thus been outlined, rather broadly, the more important features of the invention in order that the detailed description thereof may be better understood, and in order that the present contribution to the art may be better appreciated. There are additional features of the invention that will be described hereinafter and that will form the subject matter of the claims appended hereto.

In this respect, before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and to the arrangements of the components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments and of being practiced and carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein are for the purpose of the description and should not be regarded as limiting.

A primary object of the present invention is to provide a dry-wet thermal management system that will overcome the shortcomings of the prior art devices.

A second object is to provide a dry-wet thermal management system for providing simultaneous spray cooling and dry cooling for a plurality of cards sharing a common backplane.

Another object is to provide a dry-wet thermal management system that is cost effective and efficient.

An additional object is to provide a dry-wet thermal management system that has a reduce weight and size.

A further object is to provide a dry-wet thermal management system that reduces the cost of electronic devices utilized by reducing the need for coolant tolerant specifications.

Another object is to provide a dry-wet thermal management system that reduces coolant loss within a spray cooling system by reducing access to the spray chamber.

A further object is to provide a dry-wet thermal management system that effectively cools low heat flux and high heat flux electronic components.

Another object is to provide a dry-wet thermal management system that utilizes a common backplane for electronic cards positioned within a dry chamber and a spray chamber.

An additional object is to provide a dry-wet thermal management system that increases system reliability and access.

Other objects and advantages of the present invention will become obvious to the reader and it is intended that these objects and advantages are within the scope of the present invention.

To the accomplishment of the above and related objects, this invention may be embodied in the form illustrated in the accompanying drawings, attention being called to the fact, however, that the drawings are illustrative only, and that changes may be made in the specific construction illustrated and described within the scope of the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Various other objects, features and attendant advantages of the present invention will become fully appreciated as the same becomes better understood when considered in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the several views, and wherein:

FIG. 1 is an upper perspective view of a prior art dry cooling device.

FIG. 2 is a front view of the present invention illustrating the spray chamber and the dry chamber.

FIG. 3 is a front perspective view of the present invention.

FIG. 4 is a rear perspective view of the present invention illustrating the common backplane.

FIG. 5 is an exploded rear perspective view of the present invention illustrating the seals

FIG. 6 is a rear perspective view of the present invention utilizing a secondary backplane connected to the main backplane.

FIG. 7 is a front perspective view illustrating an alternative variation of the spray chamber.

FIG. 8 is a front perspective view illustrating an alternative variation of the dry chamber.

FIG. 9 is a rear perspective view of an alternative variation of the dry chamber.

DETAILED DESCRIPTION OF THE INVENTION

A. Overview

Turning now descriptively to the drawings, in which similar reference characters denote similar elements throughout the several views, FIGS. 2 through 9 illustrate a dry-wet thermal management system **10**, which comprises a chassis **20** having a dry chamber **28** and a spray chamber **26**, a first opening **22** within a rear portion **21** of the chassis **20** extending into the spray chamber **26**, a second opening **24** within the rear portion **21** of the chassis **20** extending into the dry chamber **28**, and a main backplane **40** secured and sealed to the rear portion **21** of the chassis **20**. Electronic cards **12** may be electrically coupled within sockets **42** of the main backplane **40** within both the dry chamber **28** and the spray chamber **26**. The cards **12** within the spray chamber **26** are typically high heat flux components with increased cooling requirements and the cards **12** within the dry chamber **28** are typically low heat flux components with reduced cooling requirements and/or are not compatible with the cooling fluid of spray chamber **26**. A spray cool system is within the spray chamber **26** and a dry cool system is within the dry chamber **28**.

B. Chassis (Dry Chamber and Wet Chamber)

As shown in Figures 2 through 9 of the drawings, the chassis **20** may have various shapes, structures and configurations. The chassis **20** illustrated in the drawings should not be interpreted to limit the scope of protection of the present invention. Chassis **20** may be freestanding or mounted into a rigid structure, such as but not limited to a network rack.

More particularly, the chassis **20** has at least one dry chamber **28** and at least one spray chamber **26**. The dry chamber **28** and the spray chamber **26** may be

separated within the chassis **20** by a solid divider wall **30** as shown in Figures 2 and 3 of the drawings.

The dry chamber **28** and the spray chamber **26** also are preferably enclosed by access doors/panels (not shown) as is well known in the art. The access door/panel connected to the spray chamber **26** preferably is sealed to the spray chamber **26** to prevent coolant loss. It can be appreciated that the access doors/panels for the spray chamber **26** and the dry chamber **28** may be connected to one another or comprised of a single structure.

The dry chamber **28** and the spray chamber **26** may be positioned within an overall structure as separate compartments (see Figures 7 and 8) or attached to one another (see Figure 9). Figure 7 illustrates the dry chamber **28** completely or partially surrounding the spray chamber **26**. Figure 8 illustrates the spray chamber **26** completely or partially surrounding the dry chamber **28**. Figure 9 illustrates a dry chamber **28** attached to the spray chamber **26** utilizing conventional fasteners thereby allowing "swapping" of the dry chamber **28** or the spray chamber **26** with a new chamber **26**, **28**.

The dry chamber **28** is designed to allow for airflow to pass through and make contact with the dry cards **12** within the dry chamber **28**. Various well-known dry cooling technologies may be utilized to pass air through the dry chamber **28**. For example, a fan **50** may be fluidly connected to the dry chamber **28** as shown in Figures 2 through 9 of the drawings.

In addition, the dry chamber **28** preferably includes a plurality of vents **29** within the walls, floor and ceiling of the dry chamber **28** allowing for the free flow of air thereby maintaining a desired temperature of the electronic cards **12** within the dry chamber **28**.

The spray chamber **26** is designed to allow for liquid coolant to contact the cards **12** thereby conducting the thermal energy generated by the wet cards **12**. Various well-known liquid coolant thermal management technologies may be utilized within the spray chamber **26** for thermally managing the wet cards **12** within the spray chamber **26**. The cards **12** positioned within the spray chamber **26** must be capable of being positioned within a dielectric coolant.

For example, a spray unit **60** is preferably positioned within the spray chamber **26** and fluidly connected to a pump unit **62**. The pump unit **62** fluidly receives used coolant from within the spray chamber **26** and preferably thermally conditions the coolant through a heat exchanger prior to transmission to the spray unit **60**. U.S. Patent Nos. 5,220,804 and 6,108,201 illustrate spray cooling technology that may be utilized within the present invention and are hereby incorporated by reference into this application.

The spray chamber **26** is designed to receive at least one electronics card **12** capable of being spray cooled. The "wet cards" **12** are preferably high heat flux cards **12** that generate a significant amount of heat during operation thereof.

The dry chamber **28** is designed to receive at least one electronics card **12** capable of being dry/air cooled. The "dry cards" **12** are preferably low-medium heat flux cards **12** that generate relatively lower amounts of heat during operation thereof compared to the wet cards **12**. Dry cards **12** are generally less expensive because they do not require operation within a liquid coolant.

C. Main Backplane

As shown in Figures 2 and 5 of the drawings, a first opening **22** is positioned within a rear portion **21** of the chassis **20** extending into the spray chamber **26**. As

further shown in Figures 2 and 5 of the drawings, a second opening **24** is positioned within the rear portion **21** of the chassis **20** extending into the dry chamber **28**.

The first opening **22** and the second opening **24** may have various shapes, sizes and locations within the chassis **20**. However, the first opening **22** and the second opening **24** are preferably sized sufficiently to accommodate the sockets **42** attached to the main backplane **40** and/or the secondary backplane **44** as best illustrated in Figure 2 of the drawings.

The main backplane **40** is attached to the rear portion **21** of the chassis **20** by various attachment means such as fasteners, adhesive, sealants, brackets, clamps and the like. The main backplane **40** is preferably sealed about the first opening **22** and the second opening **24** to prevent coolant from escaping from the spray chamber **26**. It can be appreciated that only the spray chamber **26** may be sealed by the main backplane **40** since airflow through the second opening **24** will not interfere with the thermal management of the dry cards **12**.

The main backplane **40** has at least one dry socket extending into the dry chamber **28** and at least one wet socket extending into the spray chamber **26** as shown in Figure 2 of the drawings. The sockets **42** may be comprised of any electronic receptacle capable of electrically receiving a card **12**.

E. Seal

As shown in Figure 5 of the drawings, at least one seal is positioned between the rear portion **21** of the chassis **20** and the main backplane **40** for sealing about the first opening **22** and the second opening **24**. The seal may be comprised of a single structure or a plurality of seal structures.

Figure 5 illustrates a first seal **70** surrounding the first opening **22** and a second seal **72** surrounding the second opening **24**. The first seal **70** and the second seal **72** may be comprised of various structures and materials commonly utilized to construct seals. It can be appreciated that only the first seal **70** is required to operate the present invention by sealing the spray chamber **26**. The seal **70, 72** may also be formed utilizing various other materials/structures such as but not limited to sealants, resins, adhesives, gaskets, O-rings and the like.

F. Secondary Backplane

In addition to a main backplane **40**, a secondary backplane **44** may be attached and electrically connected to the main backplane **40** as shown in Figures 6 and 9 of the drawings. The main backplane **40** has at lease one dry socket extending into the dry chamber **28** and the secondary backplane **44** has at least one wet socket extending into the spray chamber **26**.

A connector member **46** is electrically positioned between the main backplane **40** and the secondary backplane **44** as further shown in Figures 6 and 9 of the drawings. The secondary backplane **44** and the main backplane **40** are preferably sealed to the rear portion **21** of the chassis **20** about the first opening **22** and the second opening **24** respectively.

G. Operation

In operation of the present invention, at least one high heat flux card **12** is positioned within the wet chamber and electrically connected within one of the sockets **42** attached to the main backplane **40** as shown in Figure 1 of the drawings. The spray chamber **26** is then sealed. In addition, at least one low heat flux card **12** is positioned within the dry chamber **28** and electrically connected within one of the sockets **42** attached to the main backplane **40** as shown in Figure 1 of the drawings. An access door/panel may then be closed upon the dry chamber **28**.

The electronic cards **12** may then be electrically operated as desired to perform a desired task. Before, during and/or after operation of the electronic cards **12**, a liquid coolant is applied to the wet cards **12** within the spray chamber **26** for thermally managing the wet cards **12**. Various sensors within the spray chamber **26** determine the coolant flow rate and coolant temperature applied to the wet cards **12** depending upon the heat flux of the wet cards **12** and the desired temperature of the wet cards **12**.

In addition to operation of the spray cooling system within the spray chamber **26**, airflow is applied within the dry chamber **28** for thermally managing the dry cards **12** within thereof. A fan **50** or similar air movement device may be utilized to cause air to flow through the dry chamber **28** thereby thermally managing the electronic cards **12**. Various sensors within the dry chamber **28** determine the amount of airflow required to maintain a desired temperature within the dry cards **12**.

If the user requires access to the cards **12** within the dry chamber **28**, the access door/panel is simply removed without having to disturb the spray chamber **26**. The user is then able to make the required additions/repairs within the dry chamber **28** and close the same in an efficient manner without losing any coolant. If the user requires access to the cards **12** within the spray chamber **26**, the access door/panel is removed. A small volume of liquid coolant may be lost in opening the spray chamber **26**, but the amount of coolant loss is less than if a larger spray chamber **26** were opened. The user is then able to make the required additions/repairs within the spray chamber **26** and close the same in an efficient manner without losing significant amounts of coolant.

As to a further discussion of the manner of usage and operation of the present invention, the same should be apparent from the above description. Accordingly, no further discussion relating to the manner of usage and operation will be provided.

With respect to the above description then, it is to be realized that the optimum dimensional relationships for the parts of the invention, to include variations in size, materials, shape, form, function and manner of operation, assembly and use, are deemed to be within the expertise of those skilled in the art, and all equivalent structural variations and relationships to those illustrated in the drawings and described in the specification are intended to be encompassed by the present invention.

Therefore, the foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly, all suitable modifications and equivalents may be resorted to, falling within the scope of the invention.